COLLAPSIBLE STRUCTURE WITH SELF-LOCKING MECHANISM AND METHOD OF ERECTING A COLLAPSIBLE STRUCTURE

BACKGROUND AND SUMMARY

[0001] The present invention relates to collapsible structures and, more particularly, to collapsible structures with self-locking mechanism and methods of erecting a collapsible structure.

[0002] My prior U.S. Patent Nos. 6,141,934, 5,651,228, 5,444,946, 5,274,980, 5,230,196, RE33,710, 4,970,841, 4,838,003, 4,800,663, 4,761,929, 4,747,239, 4,689,932, 4,666,102, 4,637,180, 4,579,066, 4,561,618, 4,522,008, 4,512,097, 4,473,986, 4,437,275, 4,334,660, 4,290,244, 4,280,521, 4,026,313, and 3,968,808 are incorporated by reference and show various collapsible structures and components therefor. In many collapsible structures of the general type described in these patents, in the course of erecting the structures, the structures must extend beyond the dimensions of the erected shelter. For example, in my U.S. Patent Nos. 5,444,946 and 5,274,980, in the course of erecting the shelters, they are typically expanded laterally outward significantly past the lateral dimensions of the finished structure. This makes it difficult to provide the structures with a cover as is typically provided on portable shelter type devices. Ordinarily, the covers are attached after erection of the frame of the structure.

[0003] Also, because the structures during erection are typically expanded beyond the footprint of the structures in their erected condition, they are generally only secured to the ground or a base after they are finally erected. This can make erection of the structures difficult. For example, in windy conditions, the structures may be blown around. This

problem can be exacerbated if there is cover material on the frame because the cover material can act as a sail and make it that much more difficult to erect the structure.

[0004] During break down of these structures, the same problems occur as during erection. The covers are ordinarily taken off and the structures are ordinarily disconnected from any ground or base supporting structures before lowering the frame.

[0005] It is desirable to provide a collapsible structure that can be erected and broken down without the need to remove a cover from the structure. It is also desirable to provide a structure that can be secured to the ground or a base while the structure is being erected or broken down.

[0006] In accordance with one aspect of the present invention, a collapsible structure with a self-locking mechanism includes a first hub, at least two struts pivotably connected at first ends thereof to the first hub and movable relative to each another between a folded position and an expanded position, and a tension member adapted to limit pivotable movement of the at least two struts such that, when in the expanded position, the at least two struts define an angle of less than 180°. The structure further includes a locking hub and at least two locking struts pivotably connected at first ends thereof to the locking hub and, at seconds ends thereof, to connection points on respective ones of the at least two struts.

[0007] In accordance with another aspect of the present invention, a method of erecting a collapsible structure includes unfolding a collapsible structure from a folded condition to a collapsed condition. A plurality of base-defining ends of a plurality of end struts of the collapsible structure are fixed in the collapsed condition to points on a surface, the points generally defining a size of a base of the structure in the erected condition. After fixing

the base-defining ends to the points on the surface, a center region of the collapsible structure is lifted to an erected height of the collapsible structure. The collapsible structure is locked in an erected condition after lifting the structure to its erected height using an internal locking arrangement of the collapsible structure.

BRIEF DESCRIPTION OF THE DRAWINGS

[0008] The features and advantages of the present invention are well understood by reading the following detailed description in conjunction with the drawings in which like numerals indicate similar elements and in which:

[0009] FIG. 1A is a side view of a collapsible structure according to an embodiment of the present invention in an erected condition;

[0010] FIG. 1B is a side view of a portion of the structure of FIG. 1A;

[0011] FIG. 2 is a side view of a collapsible structure according to an embodiment of the present invention in a folded condition;

[0012] FIG. 3 is a perspective view of a collapsible structure according to an embodiment of the present invention;

[0013] FIGS. 4A-4C are perspective views of a hub according to an embodiment of the present invention;

[0014] FIG. 5 is a side view of a collapsible structure according to an embodiment of the present invention, showing the structure in a position between a folded condition and an erected condition.

DETAILED DESCRIPTION

[0015] A collapsible structure 21 according to the present invention is seen in FIG. 1A. The structure 21 includes what is referred to for purposes of the present application as a self-locking mechanism 23, seen in isolated in FIG. 1B, for locking the structure in an erected condition. The structure 21 has a self-locking mechanism 23 in the sense that the self-locking mechanism 23 can maintain the structure in an erected condition by itself, without the need for additional locking structures. However, additional locking structures may be used with the structure 21, such as to provide additional strength.

[0016] The structure 21 includes a first hub 25 and at least two struts 27a and 27b pivotably connected at first ends 27a' and 27b' thereof to the first hub. The structure 21 includes at least two struts but will ordinarily include three or four struts (FIG. 3). Structures with more than four struts may also be provided, depending upon, for example, the shape of the structure desired. The struts 27a and 27b are preferably light weight rods, such as aluminum tubes. The hubs 25 may take a variety of suitable forms such as, for example, the form of the hubs described in U.S. Patent No. 4,280,521, which is incorporated by reference, and permit pivotal attachment of the struts.

[0017] The struts 27a and 27b are movable relative to each another between a folded position (FIG. 2) and an expanded position (FIG. 1A). The structure 21 also includes a tension member 29 adapted to limit pivotable movement of the struts 27a and 27b such that, when in the expanded position, the struts define an angle of less than 180° when viewed from the side, i.e., they are not coplanar. Of course, when viewed from the top, two struts 27a and 27b may be arranged at 180° relative to one another.

[0018] The tension member 29 may take a number of different forms. The tension member 29 may, for example, be a wire 29w that is attached to the struts 27a and 27b, a cover 29c of the collapsible structure 21, such as a fabric cover, or a base 29b to which the collapsible structure is attached. Ordinarily, multiple different tension members will be used simultaneously.

[0019] The self-locking mechanism 23 also includes a locking hub 31 and at least two locking struts 33a and 33b pivotably connected at first ends 33a' and 33b' thereof to the locking hub. The locking struts 33a and 33b are connected at seconds ends 33a" and 33b" thereof to connection points 35a and 35b on respective ones of the at least two struts 27a and 27b. The locking hub 31 is structured to limit the angle through which struts attached to the locking hub can pivot. More particularly, the locking hub 31 permits the struts to pivot through an angle greater than 180° when the struts are viewed from the side. Stated differently, the locking hub 31 permits the struts to move from a first position, such as a folded position in which the struts are all substantially parallel to one another, to a locked position that is reached after the struts pass through a position in which they lie in the same plane, i.e., are at an angle of 180° to one another when viewed from the side.

[0020] As seen in FIG. 1B, a distance D between a connection point 35a or 35b and the first hub 25 for any one the struts 27a and 27b is greater than a length L of a respective one of the locking struts 31a or 31b. However, the distance between the connection point 35a or 35b and the first hub 25 for the one of the at least two struts 27a or 27b multiplied by a cosine of an angle Θ defined by a plane P in which the connection points and of all

of the struts lie and one of the struts 27a or 27b is less than the length L of the respective one of the at least two locking struts 33a or 33b.

[0021] When erecting the structure 21, the structure is locked in place with the self locking mechanism 23 by causing the locking struts 33a and 33b to pivot through an angle greater than 90° relative to the locking hub when the locking struts are moved between a folded position (FIG. 2) and a locked position (FIG. 1A and 1B). In other words, the locking struts 33a and 33b pass through the plane defined by the connection points 35a and 35b, even though the combined length of the locking struts is greater than the distance between the connection points. This is ordinarily permitted to occur due to the flexibility of the components of the structure 21 such as the struts 27a and 27b, the locking struts 33a and 33b, and the tension member 29.

[0022] In order to cause the locking struts 33a and 33b to pass through the plane P, a user erecting the structure applies a force, which will ordinarily be applied upwardly to the locking hub 31, sufficient to overcome the force with which the tension member 29 resists moving the locking struts through the plane by resisting movement of the struts 27a and 27b past the predetermined degree of maximum separation. Once the locking struts 33a and 33b have passed upwardly through the plane P, the locking struts will only move downwardly through the plane by applying a downwardly directed force and, as a result, the structure 21 will remain in an erected condition. If desired, an additional locking mechanism can be provided to assist the locking struts 33a and 33b to keep the structure 21 in an erected condition. Also, as seen in FIG. 1B, it is desirable to provide a stop to prevent the locking hub 31 from extending too far upwardly and to provide support for the locking hub. The stop may take a variety of suitable forms. A stop in the

form of a hub 125 pivotably attached to first and second struts 127a and 127b that are, in turn, pivotably attached to struts 27a and 27b, respectively, is shown.

[0023] As seen in FIGS. 1A and 1B, the collapsible structure 21 preferably also includes at least two second struts 37a and 37b pivotably connected at first ends thereof 37a' and 37b' to respective ones of the at least two struts 27a and 27b. The at least two second struts 37a and 37b can be pivotably connected to the at least two struts 27a and 27b at the connection points 35a and 35b on respective ones of the at least two struts or, as seen in FIG. 1B in phantom, at points 39a and 39b between the connection points and the second ends 27a" and 27b" of respective ones of the at least two struts 27a and 27b. The lengths of the various struts and the position of pivot or connection points of the various struts will ordinarily be selected such that, when the structure 21 is in a folded condition, all of the struts will be substantially parallel to one another, as seen in FIG. 2.

[0024] As seen in FIG. 1A, the structure 21 includes at least two second hubs 43a and 43b. Second ends 37a" and 37b" of the at least two second struts 37a and 37b are pivotably connected to respective ones of the at least two second hubs 43a and 43b.

[0025] The structure 21 further includes at least two third struts 45a and 45b. First ends 45a' and 45b' of the at least two third struts 45a and 45b are pivotably connected to respective ones of the at least two second hubs 43a and 43b.

[0026] The structure 21 further includes at least two third hubs 47a and 47b. Second ends 27a" and 27b" of the at least two first struts 27a and 27b are pivotably connected to respective ones of the at least two third hubs 47a and 47b.

[0027] The structure 21 further includes at least two fourth struts 49a and 49b. First ends 49a' and 49b' of the at least two fourth struts 49a and 49b are pivotably connected to

respective ones of the at least two third hubs 47a and 47b and are pivotably connected at connection points 51a and 51b to respective ones of the at least two third struts 45a and 45b.

[0028] Similar to the pivoting of the locking struts 33a and 33b relative to the locking hub 31, the first struts 27a and 27b and the fourth struts 49a and 49b are each ordinarily adapted to pivot through an angle greater than 90° when the first struts and fourth struts pivot relative to respective ones of the third hubs 47a and 47b between a folded position and a locked position. The third hubs 47a and 47b are ordinarily arranged to permit the pairs of struts 27a and 49a and 27b and 49b to pivot through an angle greater than 180°, when the struts are viewed from the side. Stated differently, the third hubs 47a and 47b permit the struts 27a and 49a and 27b and 49b to move from a first position, such as a folded position in which the struts are all substantially parallel to one another, to a locked position that is reached after the struts pass through a position in which they lie in the same plane, i.e., are at an angle of 180° to one another when viewed from the side.

[0029] The collapsible structure 21 seen in FIG. 1A also includes at least two fourth hubs 53a and 53b. Second ends 49a" and 49b" of the at least two fourth struts 49a and 49b are pivotably connected to respective ones of the at least two fourth hubs 53a and 53b.

[0030] The collapsible structure 21 seen in FIG. 1A also includes at least two fifth struts 55a and 55b. First ends 55a' and 55b' of the at least two fifth struts 55a and 55b are pivotably connected to respective ones of the at least two fourth hubs 53a and 53b.

[0031] The collapsible structure 21 seen in FIG. 1A also includes at least two fifth hubs 57a and 57b. Second ends 45a" and 45b" of the at least two third struts 45a and 45b are pivotably connected to respective ones of the at least two fifth hubs 57a and 57b.

[0032] The collapsible structure 21 seen in FIG. 1A also includes at least two sixth struts 59a and 59b. First ends 59a' and 59b' of the at least two sixth struts 59a and 59b are pivotably connected to respective ones of the at least two fifth hubs 57a and 57b. The at least two sixth struts 59a and 59b are pivotably connected to respective ones of the at least two fifth struts 55a and 55b at connection points 60a and 60b.

[0033] Similar to the pivoting of the locking struts 33a and 33b relative to the locking hub 31, and the pivoting of the first struts 27a and 27b and the fourth struts 49a and 49b relative to the third hubs 47a and 47b, the third struts 45a and 45b and the sixth struts 59a and 59b are ordinarily each adapted to pivot through an angle greater than 90° when the third struts and sixth struts pivot relative to respective ones of the fifth hubs 57a and 57b between a folded position and a locked position. The fifth hubs 57a and 57b are ordinarily arranged to permit the pairs of struts 45a and 59a and 45b and 59b to pivot through an angle greater than 180°, when the struts are viewed from the side. Stated differently, the fifth hubs 57a and 57b permit the struts 45a and 59a and 45b and 59b to move from a first position, such as a folded position in which the struts are all substantially parallel to one another, to a locked position that is reached after the struts pass through a position in which they lie in the same plane, i.e., are at an angle of 180° to one another when viewed from the side.

[0034] A collapsible structure 21 having four strut and hub arrangements extending radially from a centerpoint is shown in FIG. 3. Here, the collapsible structure includes

four struts 27a, 27b, 27c, and 27d pivotably connected at first ends thereof to the first hub 25. The struts 27a, 27b, 27c, and 27d are spaced relative to one another about the first hub 25 at 90° and are movable relative to each another between a folded position and an expanded position. A tension member such as a wire 29w attached to the first struts 27a, 27b, 27c, and 27d is provided that is adapted to limit pivotable movement of the struts such that, when in the expanded position, the four struts define an angle of less than 180°.

[0035] Four locking struts 33a, 33b, 33c, 33d are pivotably connected at first ends thereof to the locking hub 31. The locking struts 33a, 33b, 33c, 33d are connected at seconds ends thereof, to connection points 35a, 35b, 35c, 35d on respective ones of the four struts 27a, 27b, 27c, and 27d. Four second struts 37a, 37b, 37c, and 37d are pivotably connected at first ends thereof to respective ones of the four struts 27a, 27b, 27c, and 27d. Four second hubs 43a, 43b, 43c, 43d are provided. Second ends of the four second struts 37a, 37b, 37c, and 37d are pivotably connected to respective ones of the four second hubs. Four third hubs 47a, 47b, 47c, 47d are provided. Second ends of the four first struts 27a, 27b, 27c, and 27d are pivotably connected to respective ones of the four third hubs 47a, 47b, 47c, 47d.

[0036] The four strut and hub arrangements may be tied together by extension arrangements including four extension hubs 61a, 61b, 61c, 61d, eight extension struts, 63a1, 63b1, 63c1, 63d1, 63a2, 63b2, 63c2, 63d2, and eight extension arms 65a1, 65b1, 65c1, 65d1, 65a2, 65b2, 65c2, 65d2. Four pairs 63a1 and 63a2, 63b1 and 63b2, 63c1 and 63c2, and 63d1 and 63d2 of the eight extension struts are pivotably connected at first ends thereof to respective ones of the four second hubs 43a, 43b, 43c, 43d at right angles to the second struts 37a, 37b, 37c, 37d and are pivotably connected at second ends thereof

to respective ones of the four extension hubs 61a, 61b, 61c, 61d. Four pairs 65a1 and 65a2, 65b1 and 65b2, 65c1 and 65c2, and 65d1 and 65d2 of the eight extension arms are pivotably connected at first ends thereof to respective ones of the four third hubs 47a, 47b, 47c, 47d at right angles to the first struts 27a, 27b, 27c, 27d and each of the eight extension arms are pivotably connected at second ends thereof to respective ones of the eight extension struts 63a1 and 63a2, 63b1 and 63b2, 63c1 and 63c2, and 63d1 and 63d2. In addition to tying together the four strut and hub arrangements, the extension arrangements can provide a collapsible structure 21 with sides that are more vertical, thus providing more usable space within the structure. Instead of or in addition to the extension arrangements described, however, additional strength and suitable side verticality can be obtained by providing a self-locking mechanism substantially like the mechanism 23 and having at least two scissors instead of the single scissor formed by the struts 55a and 59a, 55b and 59b, 55c and 59c, and 55d and 59d.

[0037] Turning to the embodiment shown in FIG. 1A, the locking hub 31, the third hubs 47a, 47b, and the fifth hubs 57a, 57b may be in the form of U-shaped channel structures 67 as shown in FIGS. 4A-4C. The type of hub shown in FIGS. 4A-4C limits the amount that the struts can pivot and is particularly well-suited for use as the locking hub 31, the third hubs 47a, 47b, and the fifth hubs 57a, 57b. The first hub 25, the second hubs 43a, 43b, and the fourth hubs 53a, 53b may also be of the form shown in FIGS. 4A-4C. Struts 69 are pivotably attached to the channel structure 67 by pivot pins 71. The struts 69 can be folded so that they are substantially parallel to one another as seen in FIG. 4A. The struts 69 can be unfolded past a position in which they are substantially coaxial and lie in a common plane, i.e., they are disposed at 180° to one another and have each pivoted 90°

from their initial, folded position as seen in FIG. 4B. The struts 69 can be pivoted to a point where they are blocked from pivoting further by the channel structure 67, as shown in FIG. 4C. As shown in FIG. 4C in phantom, additional channels 67' can be attached to a main channel 67 to permit additional struts 69 to be attached. In the embodiment of the collapsible structure 21 shown in FIG. 3, the locking hub 31, the first hub 25, the second hubs 43a, 43b, 43c, 43d, and the third hubs 47a, 47b, 47c, and 47d can be arranged to have four struts attached to them.

[0038] A method of erecting a collapsible structure 21 is seen in FIGS. 2, 5, and 1A. In the method, a collapsible structure 21 is unfolded from a folded condition as seen in FIG. 2 to a collapsed condition as seen in FIG. 5. While in the collapsed condition, a plurality of base-defining ends 73a and 73b of a plurality of end struts such as the fifth struts 55a and 55b or the sixth struts 59a and 59b or both are fixed to points 75a and 75b on a surface such as the ground or a base structure 29b. The points 75a and 75b generally define a size of a base of the structure 21 in the erected condition. After fixing the base-defining ends 73a and 73b to the points 75a and 75b on the surface, a center region of the collapsible structure 21 is lifted to an erected height as seen in FIG. 1A. The collapsible structure 21 is locked in an erected condition after lifting the structure to its erected height using an internal locking arrangement 23 of the collapsible structure.

[0039] The internal locking arrangement 23 includes the first hub 25. At least two struts 27a and 27b are pivotably connected at first ends 27a' and 27b' thereof to the first hub 25 movable relative to each another between a folded position (FIG. 2) and an expanded or erected position FIG. 1A. A tension member such as a wire, a cover, or a base limits pivotable movement of the at least two struts 27a and 27b such that, when in the erected

position, the at least two struts define an angle of less than 180°. A locking hub 31 is provided. At least two locking struts 33a and 33b are pivotably connected at first ends 33a' and 33b' thereof to the locking hub 31 and, at seconds ends thereof, to connection points 35a and 35b on respective ones of the at least two struts 27a and 27b. Each of the locking struts 33a and 33b is pivoted relative to the locking hub 31 through an angle greater than 90° between a folded position of the locking struts when the collapsible structure is in the folded condition (FIG. 2) and a locked position of the locking struts (FIG. 1A) when the collapsible structure is in the erected condition.

[0040] The structure 21 shown in FIGS. 2, 5, and 1A is simple to erect particularly in view of the fact that the base-defining ends 69a and 69b of the structure can be fixed in place before erecting the structure. Also, the structure 21 can be provided with a cover that can remain on the structure at all times and need not be detached during erection or during break down. A user can then stand inside of the structure 21 and lift the locking hub 31 upwardly to lock the locking mechanism 23. The structure 21 need not be splayed across the ground prior to erection and can be set up in minimal space.

[0041] The structure 21 will remain in the erected condition shown in FIG. 1A until the locking arrangement 23 is moved to an unlocked position by pulling downwardly on the locking hub 31 and the locking struts 31 so that the locking struts again pass through a plane in which they are coplanar. When collapsing the structure 21, it can be collapsed by "imploding" it, without the need for expanding the structure outwardly beyond the confines of the outline of the base of the structure.

[0042] If desired, the structure 21 can be further supported in the erected condition by additional structures, such as structures designed to prevent unlocking of the locking

arrangement 23 such as cords, chains, clips, and the like. As seen in FIG. 1, a cover 29c is ordinarily provided on the outside of the structure 21. If desired, a cover (not shown) can also be provided on the inside of the structure.

[0043] While this invention has been illustrated and described in accordance with a preferred embodiment, it is recognized that variations and changes may be made therein without departing from the invention as set forth in the claims.